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HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 58

MANGO CULTURE IN HAWAII

BY

W. T. POPE, Horticulturist

Issued October, 1929

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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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INTRODUCTION

The mango has occupied one of the most important places in the work of the Hawaii Experiment Station since the establishment of the horticultural division in 1903. Higgins (*2*)[1] in 1906 reported upon the mango in Hawaii in rather a general way, and (*3*) in 1910 described a method of propagating the mango; and Van Dine (*12*) in 1906 published the results of a local investigation on the mango seed weevil (*Cryptorhynchus mangiferæ*). Publications on this earlier work are no longer available for distribution. This bulletin has been prepared to satisfy the increasing demand for general information on the subject in the Territory.

Mango investigations, principally for the purpose of learning the best methods of propagating the tree, its cultural requirements, and the commercial possibilities of a number of varieties found growing in various parts of the Territory, were begun at the station in 1921. Of the three lines of work, that dealing with propagation was considered of the greatest importance, and it has therefore received the most attention. Nearly all the mango trees in Hawaii have been

[1] Reference is made by italic numbers in parentheses to "Literature cited," p. 26.

propagated from seed. Seedlings will often produce good fruit, but they can not always be relied upon to reproduce the variety. (Pl. 1, A.) The establishment of standard varieties of good quality is necessary for the commercial success of the mango as for most other orchard fruits. In order to insure early bearing, productiveness, and uniformity of fruit, which are the requirements in commercial-orchard development, it is necessary to use some vegetative methods of propagation. Inarching, budding, and other forms of grafting have been used to some extent in mango culture in Hawaii, but their adoption has been slow. These vegetative methods are attended by difficulties, and the percentage of successful unions resulting from them is small. Some years ago the method of top-grafting old seedling mango trees was considerably discussed and in a small way adopted. The greatest needs of the Hawaiian mango industry at present are an increased production of young grafted nursery stock of choice, standard varieties and the development of commercial orchards.

HISTORY AND DISTRIBUTION

The mango is indigenous to a large tropical area of southern Asia. In parts of that continent it is believed to have been in cultivation for over 4,000 years. Its prominence in Hindu mythology and religious observance is said to leave no doubt as to its antiquity. Few other fruits have the historical background of the mango or seem to have been so closely associated with the folklore and religious ceremonies of a great race of people.

From southern Asia the species spread to practically all the tropical world. The tree is adapted to the great range of conditions under which it is now found growing, and the fruit occupies a conspicuous place in the dietary of millions of people in the Tropics. Early Spanish and Portuguese explorers and traders introduced the mango into various parts of the tropical world. Spanish traders are thought to have carried the mango from the Philippine Islands to the west coast of Mexico long before the discovery of the Hawaiian Islands by Englishmen in 1778. The Portuguese are also known to have brought this valuable fruit to the western world. It was planted in Brazil by them at an uncertain date, presumably in the early part of the eighteenth century. The mango evidently met with much favor, and under the climatic and fertile soil conditions of the New World it grew in great profusion. In 50 years it spread widely to a number of places and was grown particularly in the vicinity of Rio de Janeiro. It was carried from there to the West Indies and reached Barbados, whence it spread to most of the other islands of the great archipelago. In 32 years after the mango tree was introduced into Jamaica it was said to be commonly found in that island.

INTRODUCTION INTO HAWAII

The mango is believed to have first reached Hawaii from the west coast of Mexico some time in the early part of the nineteenth century, probably between 1800 and 1820. It was probably introduced by Don Francisco de Paul Marin, a Spanish horticulturist. Don Marin, during his residence in Hawaii, 1791 to 1837, is credited with hav-

A.—A mango seedling tree of good variety produced this poorly flavored, fibrous fruit. The variation can be avoided by grafting. Seed at right. B.—(1) Side-tongue method of grafting; (2) Pirie scion on 10-months-old seedling; (3) and (4) modified inarch, basal end of scion. No. 3 standing in small container of water. This method was successful but was surpassed by the side-tongue method

A.—Mango graft wood showing nature of material from three different varieties. It should be young, firm, plump, and ready to make new growth. B.—Grafted mango trees in the nursery. The experiment included 350 trees of 7 varieties and resulted in 96 per cent of successful grafts. The trees at 10 months are now ready to set in the orchard

ing introduced into the Hawaiian Islands many valuable plants which have since added much to the happiness and wealth of the people. He conducted experimental gardens in several localities which have since become parts of the city of Honolulu. On two of the old sites large, aged mango trees of the Manini type are still growing. Don Marin was known by the early Hawaiians as "Manini." Hawaiians as well as the early local missionaries distinguished the early Manini type of mango from those introduced later (*15, p. 134*). The early type of mango was the source of the strain which is now known as the Hawaiian mango. (Pl. 18, B.) In more recent years a number of varieties have been developed having one or more desirable qualities, as flavor, prolificacy, or resistance to fruit-fly attack. The next most notable introduction following that of the Manini mango was made by Joseph Marsden, in 1885. He had long been in the employ of the Hawaiian Government and was well informed regarding the fruit situation of the islands. Upon returning to Hawaii from Jamaica he brought several mango trees, presumably seedlings, which were received under the varietal numbers 5, 7, 9, and 11. The supposition that these were type or varietal numbers is substantiated to considerable extent by the fact that the fruit of each seedling though subject to common variations has continuously reproduced certain general characters. These characters may be identified as parental relations belonging to one or another of the mangoes of the West Indian race, just as is evident in the Pirie type of the Alphonse race, and in seedlings of the Cambodiana type. The original trees Nos. 5, 7, 9, and 11, were planted in the Government nursery on King Street, Honolulu. Nos. 5 and 9 are still living and have been the source of many good trees. This is particularly true of No. 9, which is now one of the most widely known varieties in the Territory. (Pl. 4, A.)

In recent years the standard of good mangoes in the Territory of Hawaii has been greatly raised by the introduction of a number of the best Indian races and varieties. The late S. M. Damon, of Honolulu, who was for many years greatly interested in horticulture, introduced into Hawaii a number of inarched trees which have since come into bearing. G. P. Wilder and others also have introduced a number of good varieties. The station, through the United States Department of Agriculture, has from time to time made introductions which have been the basis of experimentation as to methods of propagation and culture.

METHODS OF PROPAGATION

In the latter part of 1921, 1-year-old seedlings in nursery rows were grafted by the shield budding, whip-graft, wedge-graft, and side-tongue-graft methods. (Pl. 1, B.) About 15 per cent of successful grafts were made, but the methods tried did not prove to be satisfactory. The trees could not be easily and quickly removed for transplanting to their permanent places because of the tenacious nature of the soil. It was soon found that young seedlings which are grown in "made-up," sterilized soil in 1-gallon tin containers [2] make

[2] Slightly defective gallon tins can sometimes be obtained at the local fruit canneries. In preparing the cans for use the tops should be removed by cutting around the can just below the top, and four or five large nail holes should be punched in the bottom for drainage.

better growth and can be more easily grafted and cared for during the preliminary stage of preparing standardized varieties for the orchard. Potted seedlings can be kept free from nut grass and other weed growth and from attack by soil insects if the tins are placed on large, flat-topped nursery tables in the open with the sunlight upon them.

SEEDLING STOCK

Stock plants are best developed from selected seeds of the sturdy Hawaiian type. The selections preferably should be made about two weeks after the fruit has begun to ripen. Seeds of the early-ripening mangoes are rarely as vigorous as seeds that are collected during the mid-fruiting season. Hawaiian mango seeds are mostly polyembryonic in character, several plants commonly growing from a single seed. These multiple forms are not results of cross pollinations but are mostly vegetative developments from the seed tissues of the parent tree (*7, p. 107*). Inferior seedlings which are found growing among them should be discarded at the time of transplanting. The seed should be planted as soon as possible after it is removed from the fruit. Better results are had by removing the husks immediately before planting the kernels. This may be done by clipping away a portion of the edge with the pruning shears, taking care not to damage the kernel within. The husk is hard to handle when it is wet or slippery and should be rolled in coral sand before attempt is made to remove the kernel.

At the station the mango seed has been found to germinate best when it is planted in large propagating benches of washed coral sand in the open sunlight. A convenient size of bench is 1 foot deep, 3 feet wide, and 12 feet long. The kernels should be planted about 2 inches apart each way, and be placed edgewise to a depth of 3 inches. Under Hawaiian conditions the requirements for mango-seed germination are mainly moisture and aeration. Exposure of the seed bed to the heat and light of the sun tends to develop stocky seedlings. The seed will germinate about two weeks after it is planted, and the resulting seedlings will attain a height of 6 to 8 inches in the next five or six weeks. They should then be transplanted to gallon tin containers or to 8-inch pots. Mango seedlings usually require from six to eight months from date of planting the seed to reach a suitable size for grafting. The seedlings should have a stem diameter of three-eighths inch or more at the point selected for making the union. Young mango stock trees may be maintained in the containers for about a year without becoming seriously potbound. The soil about the roots should not be allowed to become so dry as to retard growth. Forced growth should also be avoided while the roots are confined in the containers. A pint of a solution of nitrate of soda, dissolved in water at the rate of 1 ounce to the gallon, should be applied to the soil of each seedling about a week before grafting. This will usually produce a sudden activity of growth (flush), generally considered desirable at the time grafting is done.

SCION WOOD

The nature of the scion wood varies considerably in the different varieties of mangoes. In general it should consist of thrifty terminal

A.—The side-tongue graft: (1) and (2) Scion shaped; (3) stock cut for the union; (4) scion in place; (5) union, including scion, ready to be coated with paraffin. B.—Grafted Victoria mango in the orchard. The tree was approaching the completion of its third year and carrying 22 fruits

A.—An 11-year-old mango tree of the variety No. 9. B.—The Wootten mango, station accession No. 840. An excellent variety of the Hawaiian race of mangoes

growth. Sometimes, when grafting material is scarce, a second cut may be used from a branch if the wood is in good condition. Scion wood should be healthy, clean, plump, firm, and measure about three-eighths to one-half inch in diameter. (Pl. 2, A.) The scion wood should be cut at least one day before it is used, packed in damp Sphagnum moss, and then wrapped in oiled paper. Stored in a moderately cool place, it may be kept for six to eight days without seriously deteriorating. Such scion wood should be 5 to 6 inches long, so that the basal end can be cut to expose fresh wood at the time grafting is done. The leaves should be removed with a clean sharp knife or pruning shears, and only stumps of the petioles about one-eighth inch long should be left. Care should be taken to avoid injuring the buds in the axils. In the side-tongue method of grafting the terminal buds need not be in a flushed condition, as is considered desirable in some other kinds of graft wood.

SIDE-TONGUE GRAFTING

The side-tongue method of grafting young mango trees involves certain specific requirements. Both the stock and the scion must be vigorous and in an aseptic condition. The graft must be a clean operation, free from contamination. A sharp knife should be used for the work. A perfect cutting edge can be maintained by occasionally whetting the knife on a good, hard oilstone, which should be kept near at hand. Before the blade is used it should be thoroughly cleansed in alcohol and dried with a clean cotton cloth. The operation from the beginning of the cut to the completion of the union should be done without delay. The cut surfaces should be 2 to 2½ inches long and should be smoothed off so that they will fit perfectly when placed together. (Pl. 3, A.) The edges of the cut surfaces should not be bruised. The tongues are cut in the beveled surfaces to aid in holding the united parts together and to afford a greater surface of cambium where growth unites the stock and the scion. The union should be bound firmly with strips of moist raffia, which tends to tighten as it dries. The firmness of the binding is of vital importance to the success of the graft. The whole outer surface of the union, including the tying material, should be protected from outside contamination by a coating of paraffin. A low-melting paraffin, 120° F., such as is used for sealing over the surface of jellies in glass jars and similar containers, is best. A paraffin coating offers an advantage over such other coverings as waxed tape and grafting wax, which sometimes are used for the purpose. When paraffin is melted to a lukewarm liquid it is easier to apply with a brush and is better adapted to filling cracks and crevices than are the harder waxes. It is clean, waterproof, durable, and inexpensive.

In an article by Seymour (*8, p. 124–126*), R. T. Morris is reported to have found that the application of a coat of paraffin to the whole outer surface of the scion will prevent evaporation before the union is sufficiently formed to provide additional moisture from the stock equivalent in amount to that lost through transpiration. That this is true has been fully verified in a number of experiments at the station during the last four years. (Pl. 2, B.) The translucency

of the paraffin not only permits the action of light on the chlorophyll in the green bark to continue, but it also modifies the heat rays. Doctor Morris also says that a coat of paraffin does everything that a protective covering should do and nothing that it should not (*8, p. 125*).

CULTURAL REQUIREMENTS

CLIMATE

The mango is strictly a tropical tree. It adapts itself to a wide range of temperatures above freezing. In the Hawaiian Islands the mango grows in most localities from sea level to an elevation of over 1,000 feet, but its fruitfulness depends mainly upon the time of rainfall and to some extent upon the amount of precipitation. The mango fruits best at lower elevations having moderate rainfall (40 to 60 inches a year), with a cessation of the heavier rains from just before the period of blossoming in the early spring through the main fruiting season of the early summer. Differences in temperature, moisture, and possibly in soil, tend to produce some fruit in the different localities during nearly every month of the year. The best localities for mango production in Hawaii have a mean temperature varying from 70° F. in January to 78° in August. In Hawaii the mean temperature decreases about 3° from sea level to an altitude approximating 1,000 feet. The rainfall varies widely in amount in different localities of uniform elevation but increases greatly at elevations of 1,000 feet.

SOIL

The mango is not exacting in its soil requirements. It apparently thrives as well on the decomposed basaltic soils as on the lowlands where the coral content is high. It withstands an exceedingly wet soil, growing to great size and putting out beautiful foliage. For fruitfulness, however, the mango does best in a deep, fairly rich soil having good drainage. The mango tree has a wider range of adaptability to soil and moisture conditions and is more resistant to wind than are most other tropical fruit trees in Hawaii. These qualities, combined with its habit of prolificacy, have enabled the mango to be grown in nearly all the home gardens of the Territory.

TRANSPLANTING

Young mango trees from the nursery should be transplanted to their permanent places in the orchard as soon as possible after they are grafted. They should have made sufficient growth, however, to withstand the shock of transplanting. Mango trees usually are ready for transplanting 10 to 12 months from date of germination of the seed. (See pl. 2, B.) Transplanting should preferably be done between flushes of new growth and before the roots become pot bound, which interferes with the normal development of the young tree. Mango trees do not have such pronounced annual periods of dormancy as do most of the deciduous fruit trees, hence are not as well adapted to nursery-row methods of planting as are most of the fruit trees of the Temperate Zone. Late winter and the spring are the most favorable seasons for transplanting. In many parts of Hawaii, however, the

mango may be transplanted during almost any month provided that water for irrigation can be had to assure sufficient moisture for growth. In orchard planting the trees should not be set less than 30 by 30 feet (48 trees to the acre) apart.[3] Even at this distance they are likely to crowd each other long before their bearing period is past. Some growers recommend planting the trees 40 and even 45 feet apart. The roots spread out in all directions and will soon grow much farther horizontally than the branches of the tops. Of the various methods for arrangement of orchard trees, that of planting on the square, so as to form rows each way, is the most suitable for cultivation.

CULTIVATION

After the land is cleared, it should be deeply and thoroughly plowed. Cultivation opens up the ground uniformly and breaks up packed material. After the ground has been thoroughly harrowed the rows should be staked out and the holes for planting dug. These should be 2 to 3 feet across and about as deep. In India the best growth was secured when about 20 pounds of fresh bone fertilizer was placed in the bottom of each hole preparatory to planting the trees. In Hawaii good surface soil may be enriched by adding one-fifth part by volume of well-decomposed barnyard manure and should be placed in the bottom of the holes before the young mango trees are set. The grafted trees should be set firmly in the soil and the natural ground line immediately surrounding the stem should be about 2 inches lower than the natural surface of the orchard to form a basin to hold water. The basin will gradually fill up as the area is cultivated during the first four or five years. In cultivating, the soil near the tree trunk should then be left undisturbed. Plantings which are made in a season of considerable wind, especially on an exposed area, may be protected by means of a temporary windbreak in the form of burlap staked on the windward side of the trees. Shade is not necessary for young trees that have been properly exposed to the sun during their last month in the nursery. During the first five years the young mango trees should be induced to make vigorous and rapid growth. After that time the aim should be to make them produce good crops of fruit. Early growth can be stimulated by the application of fertilizer and sufficient water. Mature trees, on the other hand, may be induced to flower and fruit by withholding fertilizer and water from them during certain parts of the year.

The orchard cultural methods in common practice at the station have been found particularly favorable to mango growing. During the past eight years the young trees in the experimental orchard have made good growth as the result of receiving good culture and of interplanting with cover crops. Cultivation in summer suppresses weeds and facilitates irrigation, and the planting of cover crops in winter does not result in an excess of vegetative growth or hinder fruit production. The young experimental orchard was interplanted for three years with papayas set 8 feet apart. A row of tomatoes was grown during the first year between the rows of

[3] To find the number of trees required per acre, multiply the two distances in feet at which the trees are to stand apart and divide 43,560 by the product. The quotient will show the number of trees required.

papayas. After the papayas were removed the orchard was occasionally plowed and disked to suppress weeds. Irrigation was not required during the fourth year (November, 1927, to May, 1928,) as the rainfall was sufficient.

IRRIGATION

The mango orchard is greatly benefited by irrigation in unusually dry weather. Usually the best results are obtained when the so-called rainy season begins early, from November until the end of December. The rains are almost continuous for a month or two and then drop off to light showers. A lessening of moisture tends to encourage flower-bud development. If the soil is not moist enough after the young fruit has set, the orchard should be liberally watered several times to aid in carrying the crop to maturity. It is estimated that the mango needs 40 to 60 inches of water per year, the amount varying somewhat with the retentive power of the soil and the rate of evaporation.

FERTILIZING

No systematic and careful experimenting with fertilizer for mangoes has been done in Hawaii. The station has from time to time fertilized the old mango orchard with well-rotted barnyard manure at the rate of about 12 tons per acre. Applications were made in the early fall. Manure apparently has a tendency to keep the soil in good condition for receiving and retaining moisture.

Popenoe (*7, p. 105*) refers to experiments in Cuba and in Florida, where liberal fertilization with potash encouraged the production of much larger crops than were obtained otherwise. Popenoe also states that mangoes in Florida were treated with a specially prepared commercial fertilizer containing 5 to 6 per cent of ammonia, 7 to 9 per cent of phosphoric acid, and 9 to 11 per cent of potash. These materials were derived from ground bone, nitrate of soda, dried blood, dissolved bone black, and high-grade potash salts.

COVER CROPS

In the station experiment, a leguminous cover crop has usually been grown during the fall and the winter. The cover crop seldom gets very dense, but it tends to prevent surface washing and is plowed under as soon as the ground permits at the close of the wet season. Leguminous cover crops aid in increasing the nitrogen content of the soil. Leguminous cover crops tried during the past seven years include Crotalaria (*Crotalaria juncea*), mungo bean (*Phaseolus mungo*), and the cowpea (*Vigna catjang*). The latter has proved to be the most desirable.

PRUNING

Normally the mango requires little pruning. During the first four or five years, care should be taken to form the top. The top should preferably be kept low. No branches should be left within 3 feet of the ground. Care should be taken to avoid having too many branches strike out from too near the same point; the leader and one or two side shoots may be retained, but the others should be

suppressed. In some localities it may be desirable to prune out a certain number of branches in the interior of the top so as to admit light and air. As the orchard grows older the weak and dead branches should be removed.

THE CROP

TIME OF MATURITY

Grafted mango trees come into bearing in three to six years. They are usually several years earlier than seedlings, but bear more irregularly, and the trees are more dwarfed in form. (Pl. 3, B.) Habits of early bearing and dwarf form are said to be due to the fact that the graft wood is mature fruit wood, part of a parent tree which has already passed its vegetative growth. The habit of bearing heavily one season and very lightly the next has been overcome to considerable extent by giving close attention to cultural details and by planting varieties that are known to bear regularly.

HARVESTING

For home use the fruit is generally picked when it is fully ripe. This does not correspond with the practices in some other mango-producing countries. In India the fruit is generally gathered when it is hard and then stored for ripening. The fruit, when possible, should be picked from the tree by hand. It may be gathered from the higher branches by means of stepladders and long-handled pickers.[4] For marketing purposes the fruit should be gathered while it is firm. If the fruit is picked when it is fully grown and is properly cared for it will ripen and develop its full natural flavor.

HANDLING AND STORING

The fruit should be carefully handled because it is easily bruised. The slightest injury will disfigure it and cause it to decay quickly. The fruit should be stored in the fruit room and be arranged preferably in single layers between soft dry grass. The room should be kept well ventilated and free from decided changes of temperature. A moist temperature will hasten ripening and decay. A low temperature and fresh air, on the other hand, will retard destructive changes in the fruit. Some growers prefer to ripen the fruit in the dark. The fruits keep better if each one is wrapped separately in tissue paper before it is stored. This is particularly essential where high-class mangoes are to be marketed.

Mangoes for shipment should be packed in small boxes or baskets so that the pressure will not be great on any part of the fruit. Some varieties will keep much longer after picking than others. In a number of trials at the station, well-ripened fruit of the varieties Pirie, Wootten, Victoria, Kalihi, and No. 9 kept in good condition for a period varying from 7 to 15 days at ordinary temperatures.

[4] There are several different kinds of long-handled pickers. A serviceable type consists of a soft cloth bag large enough to hold several fruits and attached to the end of a long bamboo handle. The mouth of the bag is held open with a stiff wire hoop which has a forked hook rising from one side above the end of the handle and curving part way over the circular mouth of the bag. For use in picking, this hook is slipped astride the stem of the fruit, and if given a slight twist or pull it detaches the fruit, which is then caught in the bag.

Two crates of 50 mangoes each were placed in cold storage at a temperature of 48° F. The fruit in one crate showed little change after 15 days. Specimens which were ripe when placed in cold storage retained their flavor; those which were still hard when stored ripened in several days after they were removed to warmer temperatures. The fruit in the other crate was unsatisfactory when held for 31 days at a temperature of 48° F. The ripe fruit had lost its flavor, and the unripe fruit failed to ripen with natural flavor. Evidently considerable experimenting will have to be done to learn how to keep mangoes in good condition in cold storage for periods of a month or longer. A number of similar experiments have been conducted in Porto Rico (*5*). The results with certain varieties indicate that the fruit can be successfully shipped long distances and marketed. Many growers in Florida make regular shipments in season to the large markets of New York and other cities of the east coast of the United States. Growers in both India and the West Indies also successfully ship selected mangoes to European markets.

COMPOSITION OF THE FRUIT

The composition of the mango fruit is of considerable importance to those who use it as a food. The chemical changes taking place in the fruit during the ripening period are of great interest both from a scientific and from a practical standpoint. Like some other fruits, the mango previous to ripening contains a substance, mainly in the peel, which affords the fruit protection from the attacks of insects. In some of the varieties the percentage of this substance is so high as to prevent the eggs of the most persistent fruit flies from hatching or the larvæ from developing. This substance remains so active in the peel of some varieties, even after the fruit has ripened, as to affect some people eating the fruit with what is known as "mango poisoning."

Many varieties of Hawaiian-grown mangoes have been analyzed at the station (*11*). In eight miscellaneous varieties the average edible portion was found to approximate 63.77 per cent. The total solids were a little over 20 per cent. The sugars particularly were high, the total carbohydrates amounting to 15.25 per cent, of which sucrose was the principal sugar. The acidity varied from 0.122 to 0.379 per cent. In some other varieties it is known to be even higher. The ash varied from 0.277 to 0.469 per cent. The protein had a greater variation, 0.438 to 1.075, with an average of 0.709 per cent. The fats averaged 0.171, the lowest 0.032, and the highest 0.530 per cent. Qualitative tests showed the presence of considerable amounts of tannin, but no starch appeared in the ripe fruit. The unripe fruit contains both malic and tartaric acid in considerable quantities.

USES

The Hawaiian mango is most commonly eaten as a fresh fruit. It is, however, utilized in many different ways. It may be sliced and served with cream as a dessert fruit, or used for making salads, pickles, preserves, jellies, sauces, and pies. Mango chutney is one of the most delicious and well-known fruit products of Hawaii. In India, where the mango is rather extensively grown, the fruit has a

great many uses. It is canned on a large scale much the same as peaches and pineapples are canned. Its uses in that country are described by George Watt (*13, p. 764*). Other accounts of the uses of the mango are given by G. M. Woodrow (*16, p. 255–259*) and by J. E. Higgins (*2*).

CONTROL OF ENEMIES

FUNGUS DISEASE

Mango blight (*Glœosporium mangiferæ*) is the most serious of the mango diseases in Hawaii. The spores of the fungus apparently are always present on the mango tree, on dead wood lying about, and possibly on some other species of trees. When the atmosphere is moist the fungus grows very rapidly on the foliage, young branches, and fruit, and especially on the blossoms, where it is very destructive. It appears in black splotches and causes the flowers and the small fruits to drop prematurely. Some fruits of good size may continue on to maturity although they are badly discolored and harbor the disease. If these fruits are not removed the fungus will injure the skin to such an extent as to cause it to crack and decay about the time of maturity.

CONTROL

All dead wood, weeds, and other unnecessary plants should be removed from the orchard and from adjacent surroundings. The mango orchard should be sprayed thoroughly with Bordeaux mixture two or three times within two weeks before the blossoms open. For developing fruit which shows discoloration from the fungus, a spraying with Bordeaux mixture should be followed several days later with one of oil emulsion. The fungus should be caught in the early stages of attack, because later sprayings are likely to make the skin of the fruit tender and susceptible to decay.

The following is the formula used by the station for Bordeaux mixture:

Copper sulphate (bluestone)	pounds	6
Quicklime (unslaked)	do	4
Water, enough to make	gallons	50

The bluestone should be placed in a sack and suspended in a barrel or other wooden or earthen vessel containing water until dissolved. The lime should be slaked separately, water being added very slowly at first. The lime paste should then be diluted with water up to 25 gallons. Equal parts of the bluestone and the lime solutions should be poured together into a third container. The solution should be stirred and strained into the spray tank. The mixture may be tested to learn whether it is likely to injure the foliage by holding the clean blade of a penknife in it for a few minutes. If a copper deposit is seen on the blade more lime must be added to the solution.

Oil emulsion, such as is suitable for combating many kinds of scale insects and for removing smutlike discolorations of the mango fungus can be made as follows:

Local yellow soap	pounds	½
Kerosene (coal oil)	gallons	2
Water	do	1

The soap should be dissolved in water which is boiling over a fire. The solution should then be removed to a safe distance from the fire and the kerosene added to it. The mixture should be agitated by charging and discharging the spray pump for 5 to 10 minutes or until the mixture has a creamy consistence, thickens on cooling, and shows no trace of free oil on the surface. The stock solution should be diluted with water (1 part solution to 10 to 15 parts water) when used to kill plant lice. Good oil-emulsion sprays can be obtained ready-made on the market.

INSECT PESTS

The Mediterranean fruit fly (*Ceratitis capitata*) and the mango weevil (*Cryptorhynchus mangiferæ*) are two serious pests of the mango tree in Hawaii. The Mediterranean fruit fly is believed to have become established in Hawaii about 1907 although it was not discovered there until 1910. Reaching an environment which proved to be suitable for development and free from natural parasitic enemies, the Mediterranean fruit fly soon became a serious menace to the mango and to many other kinds of fruit in Hawaii. Since 1907 investigations on the Mediterranean fruit fly have been in progress continuously at several of the local institutions. A number of reports concerning the fly have been published. Back and Pemberton (*1*, *p. 38*), of the Federal Bureau of Entomology, reported on local investigations covering three years (1912–1915), and Silvestri (*9*) reported upon his findings in Africa in 1912–13. The Bureau of Entomology of the United States Department of Agriculture, the Hawaiian Board of Agriculture and Forestry, and the Hawaiian Sugar Planters' Experiment Station are endeavoring to bring about improved local conditions by means of natural predacious enemies and the establishment of parasitic insect enemies. The horticultural division of the station is also cooperating in an effort to control the fly by breeding resistant varieties of fruit, particularly of the mango.

Notes on the Mediterranean fruit fly are given for the benefit of some of the many local growers who may not be familiar with its habits. The adult female fly is bright yellow in color with black markings and is about one-fourth inch in length. She moves nervously over maturing fruit and by means of an ovipositor inserts her eggs where the larvæ can feed on the flesh of the fruit. In the Hawaiian Islands the eggs hatch in two to six days. The small larvæ feed in considerable numbers in the maturing fruit and soon cause it to fall to the ground in a decaying condition. They then enter the soil to pass through the pupal stage. After this stage, which requires from 10 days in warm weather to 50 days in cool weather, they reappear as adult fruit flies.

The peel of the lemon, the lime, and some varieties of mango contains certain strong juices which prevent the fruit-fly eggs from hatching, or the young larvæ, which may hatch, from living. Hence the selection and cultivation of these resistant varieties of mango have proved to be of considerable importance.

The introduction of beneficial insects into Hawaii as a means of controlling certain serious insect pests has been attended by success in the past, and it is thought that the further introduction of para-

sites for the control of the Mediterranean fruit fly will eventually result in its control. The cultivation of resistant varieties and the use of parasites for the control of the Mediterranean fruit fly should offer hope of relief to the mango growers and other persons in Hawaii who are interested in the fruit.

The mango weevil (*Cryptorhynchus mangiferæ*) damages the mango crop considerably by burrowing into the seed. The weevil frequently affects the appearance of the flesh, causing it to decay from the seed outward. Weevil injury also hastens ripening and causes much of the fruit to fall prematurely. The pest was first observed in Hawaii about 1905. Its native land is uncertain. The mango weevil has long been considered a serious pest in Madagascar, India, Ceylon, the Malay region, and the Pacific islands. Extensive literature has been written pertaining to the spread of the mango weevil, particularly in India. Probably the most important reference to the mango weevil in this locality has been made by Van Dine (*12*). The insect is supposed to have reached Hawaii from the Philippines or from India, since mangoes were shipped to Hawaii from both places previous to the year of the local discovery of the pest. It could have been introduced during the developmental period in the seeds or in the hibernated state in the soil or packing about plants.

A brief description of the mango weevil and of its life cycle should be of importance to every local mango grower. The adult is a hard beetle having a beak with mouth parts at the extreme end. In length the beetle varies from one-fourth to five-sixteenths of an inch. In color it is dark brown with yellow markings. The beetle when disturbed drops to the ground and feigns death, drawing its head under the thorax and folding its legs beneath the body. The adult female lays her eggs in slight incisions on the surface of the fruit before it is half grown. The larvæ are small, whitish, and legless, and have black heads. A fruit usually contains only one larva, but occasionally may contain three or four grubs. After hatching, they immediately burrow into the husk and enter the kernel. The injury to the green flesh is so slight that all evidence of the means of entrance soon becomes effaced. The larva tunnels through the seed and often destroys or seriously injures the embryo. When fully developed, the larva constructs a pupal cell in the seed and remains inactive. It finally develops into an adult with wings, legs, and beak, and then emerges in search of a suitable place for hibernation. Observations of the life cycle were made at the station. The first adults of the season came forth from some hidden place of hibernation about May 15. The eggs were laid very shortly thereafter, and the larvæ began work in the seeds of young mangoes about the last of May. The larvæ entered the pupal stage during late June and early July. From indications it is thought that the complete life cycle requires about 40 days and that most of the rest of the year is spent in hibernation. This period may be spent in the ground, or among stones, old leaves, or other litter. The adults remained alive when they were kept without food or a change of air in a small cork-stoppered bottle for 140 days. Poisonous sprays are not a means of control, because the pest feeds within the fruit. Litter and fallen fruit may harbor large

numbers of the adult weevils and should be burned. Parasitic insect enemies of the mango weevil should be found and introduced into Hawaii as a more effective means of control.

DESCRIPTION OF VARIETIES

The varieties of mangoes described in this bulletin include introductions or developments by the station, and mangoes which were found growing in other parts of the Territory. Some of the varieties have been discussed by Higgins (*2*). They are mentioned again because they have since shown new important characters, including resistance to the attacks of the Mediterranean fruit fly (*Ceratitis capitata*) and blight (*Glœosporium mangiferœ*), both of which have become serious mango pests locally since 1906. Some other varieties of mangoes which Higgins (*2*) considered as promising previous to 1906 are not mentioned in this bulletin because they were not propagated vegetatively as varieties and have disappeared from cultivation. In this study, at least one tree of each variety which was considered to be particularly desirable was propagated vegetatively and given a place in the station orchard for further study, and possibly for utilization as a source of propagating material for distribution. The characters for determining desirability were flavor, texture, color and size of fruit, general marketing qualities, prolificacy of tree, and particularly resistance in all or any parts to attacks by insect pests and fungus diseases.

Among the several races and types of mangoes which have reached the Hawaiian Islands, the seedling trees usually perpetuate race and often type characters. However, hybrids are being developed in which it is difficult to trace these characters. (See pl. 12, B, and pl. 17, B.) An attempt has been made to list the varieties as far as it is possible within the group to which the leading characters indicate the closest relation. For the sake of convenience and of conforming with the horticultural classification of mangoes in other countries, the Hawaiian mangoes have been divided into two groups—seedling races and horticultural varieties. The latter are produced by vegetative methods of propagation. Races, types, and varieties are discussed in general by Popenoe (*7, p. 132*) (*6, p. 21–36*). The races used in this study are designated as Hawaiian, West Indian, Alphonse, Sandersha, Mulgoba, and Cambodiana.

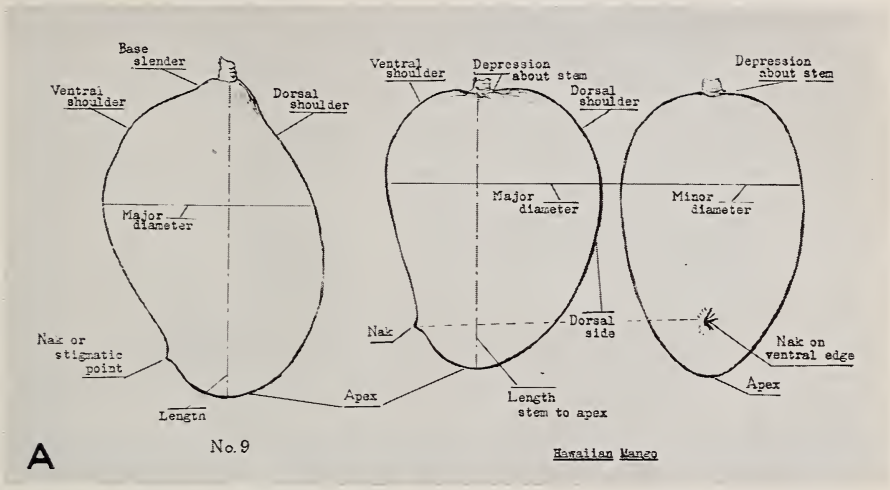
In the work of identifying mango varieties, the fruit supplies most of the characters. These characters are form, size, color, odor, surface, and nature of flesh as to color, fiber, consistency, and flavor, and size and shape of seed. Illustrations are of much assistance in determining form characters. For the convenience of the reader in understanding the form characters, an outlined chart, such as has been adopted to some extent in pomologically studying the fruit, is shown in Plate 5, A and B.

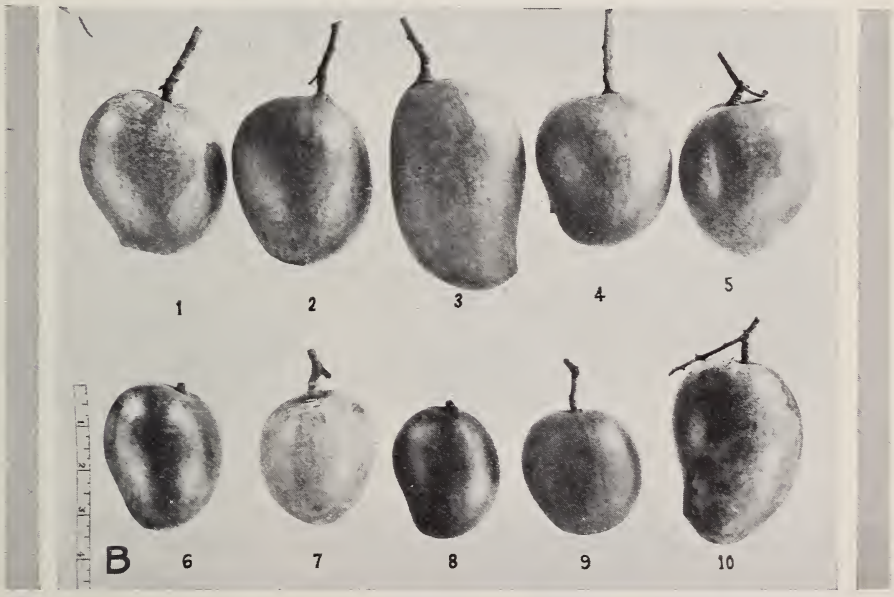
HAWAIIAN RACE

WOOTTEN

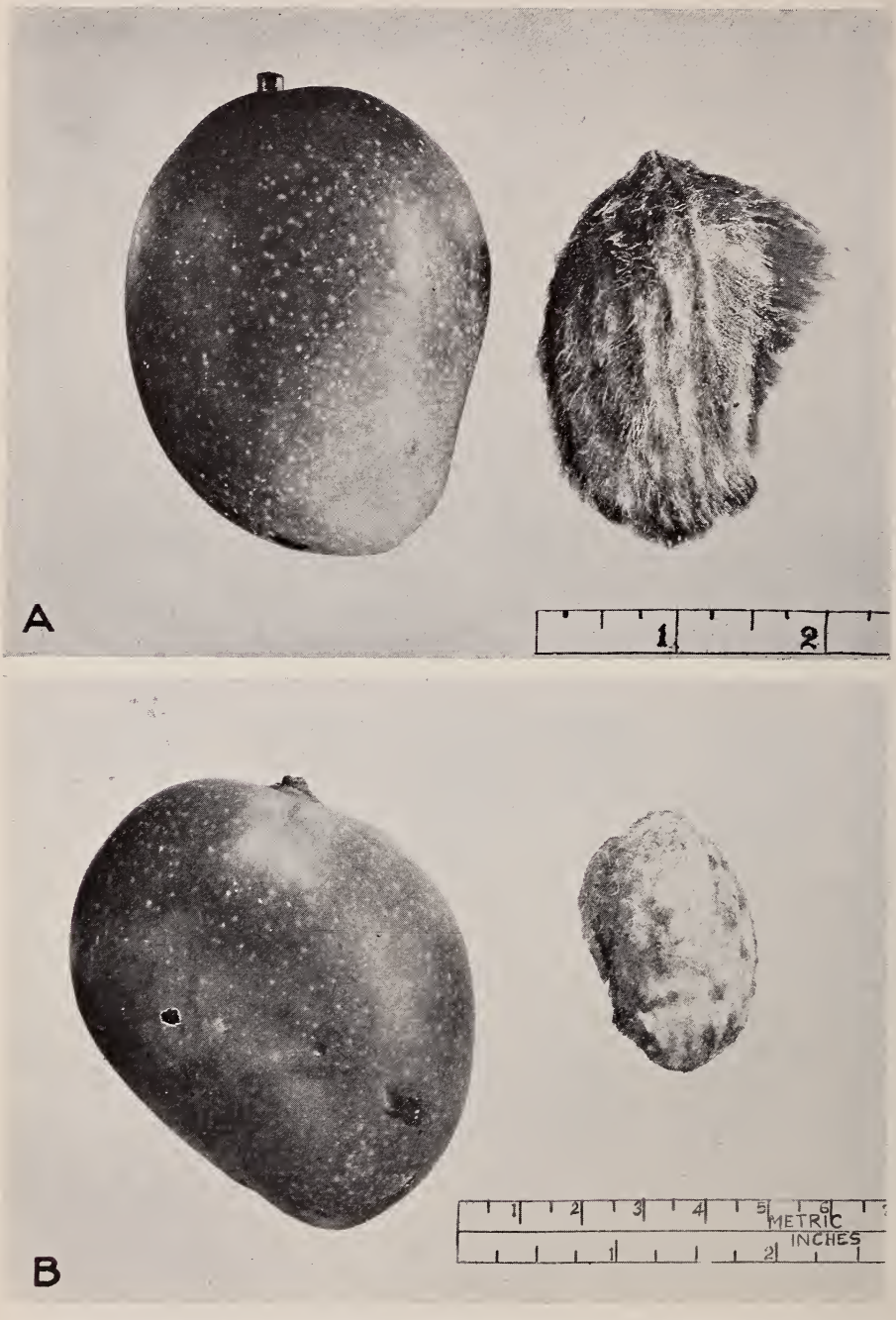
The original tree of the Wootten (No. 840)[5] (pl. 4, B), a Hawaiian seedling, was planted in the yard of Harry Wootten on Makiki Street,

[5] The accession numbers under which the varieties have been propagated at the station.





A.—Outline chart showing form characters. B.—Fruits of 10 varieties of mangoes: (1) Pirie, (2) Mulgoba, (3) Totafari, (4) Jamshedi, (5) Wootten, (6) Smith-Wootten, (7) Alphonse, (8) Hawaiian, (9) Brindabani, (10) Julie



A.—Fruit of the Whitney variety of mango. It has never been known to suffer from the punctures of the Mediterranean fruit fly. Seed at right. B.—The Roberts variety of mango is from a tree of the Hawaiian race. Its variation is supposed to be due to natural hybridization. Seed at right

in Honolulu, about 1900. The tree is vigorous and prolific, and the fruit is rarely attacked by the Mediterranean fruit fly. Mr. Wootten has propagated many trees of the variety by inarching.

Fruit.—Size, medium to large; weight, 10 to 16 ounces; form, roundish, with broad apex; stem in shallow cavity; furrow from stem extends through ventral shoulder; color, rich yellow to orange, tinged with pink and red above, and pale yellow dots over the entire surface; skin, medium to thick; flesh, firm, apricot yellow, fragrant, sweet, juicy, excellent. A very desirable fruit for marketing.

WHITNEY

The original tree of the Whitney (No. 4837) (pl. 6, A), a seedling, was grown in the yard of the late J. M. Whitney, 1325 Punahou Street, Honolulu. The tree is large, vigorous, and prolific and is now the parent of a number of grafted trees.

Fruit.—Size, large; weight, 8 to 10 ounces; weight of seed, 1 to 1½ ounces; form, oblong, broader than thick with rather extended apex; color, when ripe, greenish yellow with light specks on entire surface; skin, leathery; peeling qualities, fair; flesh, light yellow, fiber-free, melting, and of excellent sweet flavor. Marketing qualities very good.

ROBERTS

The original tree of the Roberts (No. 5148) (pl. 6, B) was grown by Harry Roberts, 1503 Houghtailing Avenue, Honolulu. This tree is thought to be a hybrid resulting from the cross of a Hawaiian with some Indian variety. The tree is vigorous and prolific. The fruit is attractive and free from the attacks of the Mediterranean fruit fly. Fruit and propagating material were obtained for study by the station in 1924.

Fruit.—Size, medium to small; weight, 6 to 10 ounces; form, rather oblique, ventral shoulder large, apex pointed; color, bright yellow with cast of red on exposed shoulder, with whitish specks on entire surface; skin, smooth, thin, and tough; flesh, yellow, juicy; little fiber mostly on the seed; flavor, sweet, subacid; general quality, excellent.

STEWARD

The original tree of the Steward (No. 5189) (pl. 7, A), a Hawaiian seedling, was planted in 1919 in the yard of C. A. Steward, Sixteenth and Harding Avenues, Kaimuki, Honolulu. The tree fruited in 1925, 1926, and 1927. It is large, vigorous, and productive. The fruit remains unusually hard until it fully matures, and has never been known to be attacked by the Mediterranean fruit fly.

Fruit.—Size, medium; weight, 7 to 10 ounces; form, oval; color, greenish to yellow, shaded on one side with scarlet; surface, uneven to bumpy; rind, thick, leathery, and rather hard until the fruit fully matures; flesh, orange, firm, with little fiber; flavor, good, slightly suggestive of turpentine, but not unpleasant. A good chutney mango and a good shipper.

LEMON CHUTNEY

Trees of the Lemon Chutney (No. 5321) (pl. 7, B) are upright in form and very prolific, fruiting in July. The Lemon Chutney probably originated as a Hawaiian seedling. It was in cultivation prior to 1906 at the station, where it was propagated vegetatively by budding. It has been briefly described by Higgins (*2, p. 31*) under the name "Lemon Chutney." The fruit is not attacked by the Mediterranean fruit fly.

Fruit.—Size, small to medium; total weight, 7 to 9 ounces; weight of seed, 1 to 1½ ounces; weight of rind, three-fourths to 1 ounce; form, oblong, slightly oblique, base full about stem, dorsal shoulder slight, ventral shoulder high with slight depression above region of stigmatic point (nak), which has no form of beak; color, rich lemon yellow; rind, rather tough; pulp, yellow, firm, slightly fibrous, subacid; quality, very good.

FARRAR

The original tree of the Farrar (No. 5297) was grown by Mr. and Mrs. Farrar, Nuuanu Valley.

Fruit.—Size, medium to large; total weight, 13 ounces; weight of seed, 1 to 1½ ounces; form, oblong, depressed around stem with broad apex; color, greenish yellow dotted with red on shoulder; rind, leathery and of medium thickness; flesh, yellow, slightly fibrous, good flavor; quality, fair.

WEST INDIAN RACE

No. 9

Variety No. 9 (No. 2432) (pl. 8, A) is now well known in Hawaii. It was introduced in 1885 under the name No. 9 from Jamaica, West Indies, by Joseph Marsden. The trees are prolific bearers. The fruit is infrequently attacked by the Mediterranean fruit fly.

Fruit.—Size, medium; weight, 10 to 13 ounces; length, 3½ to 4½ inches; form, somewhat resembling the letter S, base narrowed to the stem, dorsal shoulder very low, ventral shoulder slight; apex, narrow but rounded, not usually a distinct beak at nak; color, green with pale yellowish cast when fruit is fully mature, sometimes with a slight blush of pink on the exposed side; rind, medium in thickness and toughness; flesh, light yellow, usually rather fibrous; flavor, sweet and slightly watery to pleasing. The fruit has good keeping qualities.

LEWIS

The original tree of the Lewis (No. 5189) (see pl. 8, A) is a seedling variation of No. 9, and shows a number of the characters and the habits of growth of that parent. The fruit attracted particular attention because of its unusual flavor, which is superior to that of the fruit of No. 9. The Lewis variety has been propagated by budding and by inarching, and in the past few years has been increased by the side-tongue method of grafting. Attention was called to the superior quality of the fruit and graft wood furnished the station by Mrs. Franklyn B. Lewis of 1125 Third Avenue, Kaimuki, in 1925. The variety has been named the "Lewis" mango. The trees are very prolific and like the Victoria may bear fruit on one or two branches out of the regular season.

Fruit.—Form, oblong to slightly S-shaped, similar to fruit of No. 9, but broader; base protruding slightly to stem attachment; dorsal shoulder low; ventral shoulder high and full; apex broad and rounded, very little evidence of beak at nak; weight of entire fruit varies from 10 to 14 ounces; length, 3¾ to 4¼ inches; color, yellowish green when fruit fully ripens; rind, fairly tough; surface, smooth to undulating; pulp, yellow, firm, with very little fiber; flavor, spicy, subacid, juicy, and very pleasing. An excellent dessert fruit and a good keeper.

VICTORIA

The original tree of the Victoria (No. 4802) (pl. 9, A), a seedling of No. 9, was grown in the yard of Mr. and Mrs. George Ashley, No. 1508 Thurston Avenue, Honolulu. The place later became the property of T. G. Thrum before the tree came into bearing. The flower

A.—Fruit of the Steward variety of mango. Fruit has good shape, flavor, and shipping qualities and is immune to the attack of the Mediterranean fruit fly. Seed at right. B.—Fruit of the Lemon Chutney variety of mango. The clear lemon yellow color and firm, tart flesh probably suggested its name to the originator. Seed at right

A.—Left, seed and fruit of the No. 9 variety of mango. This variety was inarched and often grown from seed for many years in Hawaii; right, fruit of the Lewis variety, a seedling variation of the No. 9, but superior as a variety to the latter. B.—Fruit and seed of the Kalihi variety of mango. The Kalihi is a variation of No. 5, which came from the West Indies. The fruit from which the seedling came was much different in appearance from the other fruits of the parent tree and must have been a bud variation

clusters have a distinct reddish color. In form, the tree is large, spreading, and prolific; it often produces two crops in a season. The variety has been considerably extended by grafting.

Fruit.—Form, oblong, slightly S-shaped, almost as thick as broad; necked at stem end; apex broadly rounded, with curve ending in a small, blunt beak, which is sometimes replaced by a small depression; color, when ripe, brilliant vermilion, shaded over yellow background; surface marked with small, yellow dots, which become overcast where red is deepest; size, medium; total weight, about 9 ounces; weight of seed, 1 ounce; surface, smooth; shoulder has delicate powdery bloom; rind, thick, peels off well; aroma, very pleasing; ripe flesh, deep rich yellow, good texture, very little fiber; juice, sweet and subacid in flavor. Marketing qualities excellent, ranking among the best varieties in Hawaii.

EHRHORN

The original tree of the Ehrhorn (No. 4846) (pl. 9, B), was a seedling of the Victoria, grown by E. M. Ehrhorn, 2245 Oahu Avenue, Honolulu. The tree has much the same spreading form as that of the parent tree, but the fruit varies considerably from the Victoria. The varietal difference was observed with the appearance of the first crop in 1920. Since that time the variety has attracted considerable attention. The fruit was first studied at the station in 1922 and again in 1923, and graft wood was also obtained from which young trees were produced in a grafting experiment. Several of these young trees were set in the station orchard, and the rest were distributed to cooperative growers. The grafted trees are early and prolific bearers.

Fruit.—Size, medium to large; weight, 9½ to 11 ounces; weight of seed, 1½ to 1¾ ounces; form, oblong-oval, with rather tapering shoulders; base rather narrow, with stem connection slightly to dorsal side; apex broad and rounded, the stigmatic point (nak) usually in a depression; color, yellow background, mostly hidden by a mottling of pink and red; surface smooth, but more or less bumpy; rind, thick; flesh, firm, slightly fibrous, deep yellow to orange, juicy, aromatic, subacid. Like the Victoria, the Ehrhorn is a very desirable variety.

KALIHI

The original tree of the Kalihi variety (No. 4800) (pl. 8, B) was supposed to be a hybrid resulting from the cross of West Indian No. 5 and some other mango. It grew near the Kalihi stream makai of King Street, Honolulu. The trees are vigorous and prolific.

Fruit: Form, roundish, with blunt double apex. Color, a beautiful golden apricot splashed irregularly with bright red about the shoulder and dotted with yellow over the entire surface; size, medium; weight, varying from 8 to 12 ounces; seed, three-fourths to one ounce; rind, medium in thickness, smooth, peels off well; flesh, yellow to orange, firm with very little fiber, and a most pleasing aroma and delicious flavor. Good marketing qualities.

ALPHONSE RACE

ALPHONSE

The Alphonse variety (No. 278), along with several other Indian varieties, was introduced into Hawaii by the late S. M. Damon, of Moanalua Gardens, Honolulu, in 1899. The station obtained two plants from the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture (S. P. I. No. 8727), September 1, 1905, under the synonymous name of Douglas Bennett's

Alphonse. This identity is given by Popenoe (*7, p. 141*) and by Higgins (*4, p. 25*). Trees of the Alphonse variety were received from the Moanalua Gardens in 1908 and grown under accession No. 1072; from J. Farnsworth, Honolulu, in 1909, and again from the United States Department of Agriculture as Hafu, or Alphonse (S. P. I. No. 8733), and grown at the station under accession No. 2101. Grafts from some of the above-named stock bear other accession numbers.

The Alphonse which gives its name to the Alphonse group of mangoes it reported as a very excellent mango in India, but possibly because of its lack of flavor has failed to become popular in Hawaii. The fruit is not as highly colored as is the fruit of the Pirie, the favorite mango in Hawaii, but because of the prominence of the nak in some specimens this fruit is sometimes mistaken for the Pirie variety.

Fruit: Size, medium; weight, 10 to 12 ounces; form, ovate-oblique to ovate-cordate; very plump; breadth, usually greater than the distance from stem to apex (about 3¾ inches); base, obliquely flattened, slight cavity about stem attachment; apex, broadly pointed, practically no beak at the nak; surface, smooth, yellow-green to yellow-orange, often with splashes of crimson on the shoulder; skin, thick and tough; flesh, deep orange, fiber-free, firm, meaty, moderately juicy, slight aroma and mild flavor; seed, oblong, reniform, thick and with some short, stiff fiber over entire surface; general quality, good.

PIRIE

The Pirie (No. 1159) (pl. 10, A) is now the most extensively grown West Indian mango in Hawaii. Many growers consider it the best of all varieties in cultivation. It was introduced into the Hawaiian Islands by the late S. M. Damon, Moanalua Gardens, Honolulu, in 1899. The station obtained three inarched trees of the variety from the Moanalua Gardens on April 13, 1908. These were set in the orchard field C–IV as R–V–4, R–V–6, and R–V–8, respectively. The majority of the Pirie trees now found growing in the Territory have been propagated from the above-mentioned source. The station and private growers have also introduced the variety through the United States Department of Agriculture under the names of Strawberry and Peter's No. 1. The variety makes its best growth near sea-level elevations and produces its heaviest crops in alternate years. The fruit is considerably less susceptible to the attacks of the Mediterranean fruit fly than is that of many other varieties. The largest percentage of successful grafts at the station has been made with the Pirie variety of mango. Grafted or inarched mango trees rarely exceed 20 feet in height, and the rounded top eventually assumes a spreading habit. The foliage is dense and somewhat similar to that of most of the other varieties.

Fruit: Size, medium; weight, about 10 ounces; length, 4 inches; breadth, 3½ inches; form, roundish, ovate-reniform, or ovate-oblique, with a distinct beak at the stigmatic point; surface, smooth to undulating; color, when ripe greenish yellow, beautifully overcast with crimson where exposed to the sun, also marked with pale dots; skin, moderately thick; flesh, bright yellow-orange, firm, juicy, fiber-free, of pronounced and pleasant aroma and sweet, rich, spicy flavor. The seed is easily removed, so that the fruit can be cut crosswise, served in halves, and eaten with a spoon.

A.—Fruit and seed of the Victoria variety of mango. The Victoria is from No. 9 but varies considerably in color of fruit and habits of tree. B.—Fruit and seed of the Ehrhorn variety of mango, station accession No. 4846. The Ehrhorn is a variation of the Victoria but is larger and mottled red and yellow in color. The tree is prolific and the quality of fruit excellent

A.—Seed and fruit of the Pirie variety of mango, the leading Indian variety in Hawaii. It usually transmits its form characters and often its color and flavor of flesh to its seedlings. B.—Fruit and seed of the Pirie Seedling, a second generation from the Pirie. A fruit of very excellent flavor, well worth propagating as a variety

DAVIS

The original trees of the Davis (No. 5147) (pl. 11, A) was a Pirie seedling planted by Henry Davis, 1136 South King Street, Honolulu, in 1919. It resembles the Pirie closely in form and foliage. The fruit is slightly smaller, smoother, and has a more prominent beak. The original tree began to fruit in 1924 and, although it is not a heavy bearer, it has produced fruit regularly each summer since. Sometimes there are several small crops in a season, each from a different part of the tree. Careful observation has been made of the fruit, and no evidence of fruit-fly puncture has ever been found.

Fruit: Size, medium; total weight, 8½ to 9½ ounces; form, ovate-oblique, with prominent beak; shoulders full, base almost flat or slightly depressed around stem attachment; color of skin, apple-green to yellowish, with a blush on the exposed side; flavor almost identical with that of the Pirie; flesh, yellow-orange, firm, juicy, and fiber-free, sweet and aromatic; seed, small and easily removed from the half of ripe fruit when cut crosswise.

LARNACH

The original tree of the Larnach (No. 5155) (pl. 11, B) was a seedling of unknown origin and was planted in the yard of No. 1946 Makiki Street, Honolulu, about 1910. The place became the property of Judge and Mrs. A. D. Larnach about 1920. The tree soon came into fruit and has borne freely almost every year since. The fruit has attracted considerable attention.

Fruit.—Size, very large; total weight, 15¾ ounces; form, oblique-roundish; length from stem to apex, 3⅝ inches; width, 4½ inches; thickness, 3¼ inches; deep basal depression around stem, the cavity having grooves radiating from stem; ground color yellow splashed with bright red over the top and over most of the exposed side; rind, thick and leathery; flesh, yellow to light yellow, somewhat fibrous, firm, juicy, apricot flavor; keeping qualities, good.

HOLT

The original tree of the Holt (No. 3715) (pl. 12, A) was produced in a hybridizing experiment of the station by Valentine Holt in April, 1916, at the Moanalua Gardens. The hybrid seedling was set in field C–III in August, 1916, and first fruited in August, 1923. In hybridizing the mother tree variety, Cowasjee Patel was pollinated with Pirie pollen. The tree is vigorous and productive and is the source of considerable graft wood. The fruit is of good quality and is free from the attacks of the Mediterranean fruit fly.

Fruit.—Size, medium to large; total weight, 13 ounces; weight of seed, ¾ to 1¼ ounces; form, ovate to oblong-ovate; length about 4½ inches; ground color, apple-green with whitish specks at stem end. exposed sides overcast with reddish brown; stem attached in depression which has a prominent groove extending through it from ventral to dorsal; apex, broad; rather pointed toward the ventral; nak on a very broad projection; surface, smooth but irregular; rind, thick, tough; flesh, firm, deep yellow, fiber-free, juicy, subacid, aroma of the Pirie. Very good quality.

SCOTT-PIRIE

The original tree of the Scott-Pirie (No. 3714) (pl. 12, B) was produced as a varietal hybrid by Valentine Holt in 1916. The variety Scott was crossed with pollen from Pirie, April 6 to 10, 1916. The fruit was collected August 8, 1916, and the seed was

planted on the same day. The seedling was first grown in a pot and later set in the station mango orchard, field C–IV. It produced its first fruit in 1924.

Fruit.—Size, medium; weight 7 to 9 ounces; form, oval with considerable depression above a broad terminal point; ground color, yellow with bright crimson blush on one side; flesh, yellow, fiber-free, excellent flavor. Marketing qualities, excellent.

OTHER INDIAN RACES

MULGOBA

The Mulgoba (No. 4839) (pl. 13, A) as a grafted variety was introduced into the United States by the United States Department of Agriculture from Poona, India, in 1889. Since that time it has been introduced into Hawaii. Possibly the first tree in Hawaii was obtained from a Florida nursery by the late E. W. Jordan. The tree was grown in his private garden in Nuuanu Valley and has been the source of a number of inarched and grafted trees. The Mulgoba trees at the station are from the original material, having been obtained August 14, 1922, from a tree on the premises of Harry Roberts, Kalihi, Honolulu. Graft wood was also again obtained in 1924 from Walter Dillingham, Mokuleia, Oahu. The trees of the variety are symmetrical, vigorous, and prolific. The history of the introduction of the Mulgoba mango into the United States is given by Taylor (*10, p. 389*).

Fruit.—Size, large; weight, 10 to 20 ounces; form, roundish, oblique, reniform; surface, smooth and undulating; color, yellow with blush of red on base and most exposed side; entire surface specked with numerous whitish dots; skin, medium to thick, tough; seed, reniform, oval, rather large; fiber, scanty; flesh, rich apricot yellow, very tender, juicy, sweet, rich, and fragrant; quality, very good.

MULLGOA

This Indian variety (No. 2093) (pl. 13, B) has been introduced into Hawaii on several occasions and is now fairly well known as a desirable kind. The station received one small, inarched tree from the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture (S. P. I. No. 7102) on June 5, 1909, the original stock of which had been obtained from Bangalore, India. From this tree another inarch was made in field C–IV, where it is still growing. The tree is not a heavy bearer, but produces large fruit of good quality. The tree has been used as the source of considerable graft wood, which has been successfully employed in extending the variety.

Fruit.—Size, large; weight, 24 to 32 ounces; form, almost spherical; length, 3¾ inches; width, 3½ inches; thickness, 3 to 3½ inches; slightly depressed around stem attachment; apex, very broad and rounded; rind, thick and leathery; color, dull green specked with numerous whitish dots; flesh, firm, fiber-free, light green and slightly tinged with yellow; flavor, mild and pleasing; fruit may be eaten with a spoon. Seed, medium size, covered with tough husk.

JAMSHEDI

This Indian variety (No. 1201) (pl. 14, A) was received as S. P. I. No. 8734 on May 29, 1908, from Bombay, India, through the United States Department of Agriculture. From this tree an inarch was made on a seedling grown in the mango orchard in field C–IV, De-

A.—Fruit and seed of the Davis variety of mango, station accession No. 5147, a seedling of the Pirie. The fruit has been found to be free from the attacks of the Mediterranean fruit fly and of good quality. B.—The Larnach mango has the appearance of a big red apple. It is a natural hybrid. Seed at right

A.—Fruit and seed of the Holt variety of mango, station accession No. 3715. It was produced by crossing the Cowasjee-Patel with the Pirie. The quality is very good and the fruit is not attacked by the Mediterranean fruit fly. B.—Fruit and seed of the Scott-Pirie hybrid, station accession No. 3714. The variety is of good quality and free from the attacks of the Mediterranean fruit fly but is somewhat lacking in size and form

cember 12, 1908, and given accession No. 1373. The tree has borne fair crops almost every year since about 1917. Grafted trees have been produced from the tree and distributed to cooperative experimenters.

Fruit.—In general form, oval; shoulders, nearly equal; dorsal side, symmetrically rounded to apex; ventral side, tapering from middle rapidly to a rounded apex; depression about stem; size, large; weight, varies from 10 to 14 ounces; color, green even when ripe, dotted with whitish specks; surface, undulating; rind, leathery, thick; flesh, firm, slightly fibrous, greenish white; flavor, mildly subacid. The seed is of medium size, oval in outline, and rather flat laterally. The basal end tapers to the stem attachment of the fruit.

COWASJEE-PATEL (KAVASJI-PATEL)

This Indian variety (Nos. 1913, 1915, 1945, 2485) (pl. 14, B) was introduced by the late S. M. Damon, of Moanalua Gardens, Honolulu. The station obtained bud wood from the gardens in January, 1907, and again in 1910. The trees of the variety make vigorous growth but are considered shy bearers in Hawaii. Each fruit is borne singly on long stems. The fruit is very large, but otherwise it is unattractive. In size, the fruit is excelled only by that of the Sandersha variety. July is the fruiting season for this variety in Honolulu.

Fruit.—Form roundish to slightly oblique, shallow depression around stem attachment, slightly depressed in the ventral surface, apex very broad; weight varies from 16 to 28 ounces; surface smooth with slight undulations; color, pale green turning yellow upon ripening; rind, thick; flesh, light yellow; texture, excellent; flavor, mild and pleasant; general quality, fair.

SANDERSHA

The Sandersha (No. 1074) (pl. 15, A) is an Indian mango which was introduced into the United States in 1901 by the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture (S. P. I. No. 7108). In its own country the Sandersha has several synonymous names, as Soondershaw and Sandershaw. It was later introduced into Hawaii as S. P. I. No. 10665. The station obtained a small, inarched tree of the latter introduction on March 2, 1908. Both seedling and budded trees have been distributed. Several other introductions have been made. The trees are prolific bearers and the fruit ripens in the late summer and in the fall.

Fruit.—Size, large to very large; weight, 20 to 38 ounces or more; length, 6¼ to 9 inches; breadth, 3¼ to 4¾ inches; base about stem, slender; apex, broadly pointed; surface, smooth, light to golden yellow, the most exposed side often being shaded with red; entire surface, often dotted with gray; flesh, yellow to orange, firm, moderately juicy, fiber-free, aromatic; flavor, subacid; seed, long and rather thin.

BRINDABANI

The Brindabani, or "Heaven of the Hindu," (No. 1202) (pl. 15, B) was introduced into Hawaii from Saharanpur, India, as a single, inarched tree, through the Office of Seed and Plant Introduction, United States Department of Agriculture (S. P. I. No. 10627). It was received at the station May 29, 1908, and produced its first crop in 1910. From this tree the variety has been increased by methods of grafting and has been recorded as accession Nos. 1372, 1929, 2295, and 2817. The tree has been reported from India as a slow grower and

a moderate bearer. In Hawaii it is low in stature, has a broad spreading habit, and is a fairly abundant bearer from July to September.

Fruit.—Size, small; weight, 8 ounces; weight of seed, one-half to 1 ounce; form, almost spherical; color, greenish yellow tinged on side of most exposed portion with red; dots, yellow, small, numerous; surface, smooth, bloom, bluish white, rather abundant; skin, moderately thick, tough; flesh, orange yellow, coarse, juicy; fiber, abundant; seed, reniform and rather thin; flavor, sprightly, a trifle acid, but pleasant; quality, fair. Season, July to September, for the main crop at Honolulu.

TOTAPARI

The Totafari or Totapari (No. 279) (pl. 16, A) is an Indian variety which was introduced into Hawaii several times. The station in 1905 introduced an inarched tree from Bombay, India, through the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture (S. P. I. No. 8732). From this tree other inarches were made, some of which have been recorded under accession Nos. 1914 and 1930. The latter number is now being used for the present stock. The variety is not much grown, probably because the fruit is susceptible to the attacks of the Mediterranean fruit fly.

Fruit.—Form, oval to oblong-reniform, slightly beaked at nak, which is near the rounded apex; length varies from 4½ to 5 inches; total weight, 10 to 13 ounces; weight of seed, 1 to 1½ ounces; base, rounded and with stem attached squarely; shoulders, moderately filled; surface, smooth, greenish yellow in ground color, overspread with scarlet on exposed side; rind, moderately thick; flesh, bright yellow, juicy, fiber-free, moderately aromatic; flavor, subacid; quality, good.

CAMBODIANA

The Cambodiana (No. 260) (pl. 16, B) was one of the early introductions of the station. Two seedlings from Saigon, Cochin China, were obtained through the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture (S. P. I. No. 11645), September 1, 1905. The variety has reproduced fairly true from seed. It is sometimes spoken of as the "Saigon mango," but this name is rarely used in Hawaii. From these original trees others have been propagated by grafting. One of the grafted trees was set in the station orchard, field C–IV, under accession No. 2940. This tree has proved to be prolific as have other trees of the variety in other parts of the Territory. Unfortunately, the fruit is susceptible to the attacks of the Mediterranean fruit fly. This fact, however, has gradually become of less consequence since 1920.

Fruit.—Size, medium; length, 3¾ to 4½ inches; width, 2½ to 2¾ inches; weight, 8 to 10 ounces; form, oblong to oblong-ovate, compressed laterally; depression about stem; apex, pointed; surface, smooth, greenish yellow to deep yellow; dots few; skin, thin, tender; flesh, deep yellow, very juicy, fiber-free; flavor, subacid, slightly aromatic; seed, elliptical-oblong, thick, and with some short fiber on ventral edge; general quality, very good.

AMEERI

The variety known as Ameeri (No. 2100) (pl. 17, A) was introduced into the United States from Bombay, India, by the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, under S. P. I. No. 8731. The station obtained an inarched tree of the above number June 19, 1909. From this was pro-

A.—Fruit and seed of the Mulgoba, an Indian variety of mango. Of good quality but not prolific in Hawaii. B.—The Mullgoa is a large green Indian mango and a favorite with many in Hawaii. Seed at right

A.—Fruit and seed of the Jamshedi, an Indian variety of mango. Fruit large and of fair quality; tree not prolific in Hawaii. B.—Fruit and seed of the Cowasjee-Patel, an Indian variety of mango. The tree is a light yielder in Hawaii, and the fruit is large but of unattractive dull green color

A.—Fruit and seed of the Sandersha variety of mango. A late-fruiting variety now being commonly grown in Hawaii. Often individual fruits weigh 4 pounds. B.—Seed and fruit of the Brindabani, "Heaven of the Hindu." A prolific bearer but poor in quality in Hawaii. It is usually badly attacked by blight (*Glœosporium mangiferæ*)

A.—Seed and fruit of the Totafari variety of mango. The Totafari belongs to the Sandersha race but is smaller in fruit and earlier in bearing habits than are most of the other varieties of the race. The name is synonymous with Totapari. B.—Fruit and seed of the Cambodiana, representative of a great race of mangoes of southeast Asia. It was introduced into Hawaii from Cochin China through the United States Department of Agriculture

duced the inarched tree accession No. 2326, now growing in field C–IV, row 4. This tree produced a small crop in July, 1926, from one fruit of which was made the accompanying photograph. Like Mullgoa and several other Indian varieties in the orchard, the tree has never been prolific. Wester (*14*) states that the variety has been grown in Florida but has failed to attract attention as a dessert fruit. He suggests that it may prove to be useful for making preserves. In India it has been known by the name Amiri, which should not be confused with Amini, an altogether different variety.

Fruit.—Size, large; total weight, 8 to 10 ounces; weight of seed about 1¾ to 2 ounces; form, oblong-oval, slightly flattened, compressed about the base; apex, rounded; length, 4½ to 6 inches; surface, moderately smooth, undulate; color, greenish-yellow with cast of red on sun-exposed side; numerous whitish specks over most of the surface; flesh, pale yellow, moderately tender, juicy; flavor, sprightly acid; quality, very good; fiber, short, confined mostly to edge of seed; seed, comparatively small to medium. Season, July in Honolulu.

MANILA

The Manila (No. 5139) (pl. 18, A) is not abundant in the Hawaiian Islands. The trees have been introduced a number of times and some of them many years ago, but fruit of good quality is rarely seen in the local markets. Rain during the ripening season causes the fruit to crack. This probably accounts for its lack of popularity. The fruit is also attacked by the Mediterranean fruit fly. The station obtained the variety June 15, 1923, from the late William T. Brigham, 519 North Judd Street, Honolulu. He introduced a small, inarched tree of the variety from Manila, P. I., many years ago. The variety belongs to a recognized race of mangoes described by Popenoe (*6*, *p. 30*) as the "Filipino." Several other varieties including Carabao Pico, Pahutan, and Cambodiana belong to this race.

Fruit.—Form, slender, oblong, compressed laterally, somewhat narrow and oblique at the base; pointed at the apex; length, 4 to 6 inches; weight, 6 to 12 ounces; surface, smooth, pale greenish yellow or lemon yellow; dots numerous but inconspicuous, skin very thin, tough; flesh, bright yellow-orange, juicy, almost fiber-free, faint aroma, delicious flavor; seed, oblong, 3 to 4 inches, thin, contains several embryos; seedcoat, very thin and easily broken. General quality of the fruit, fair.

MANGOES OF LIMITED DISTRIBUTION IN HAWAII

The following varieties are not fully described in this bulletin, but they are worthy of propagation in Hawaii.

AMEERI HYBRID

This variety (No. 5145) (pl. 17, B) was produced by Harry Roberts, of Honolulu, about 1906. It is supposed to be a cross between Ameeri and Cambodiana. The fruit is large, often weighing over 16 ounces, and is greenish in color. The rind is thick; the flesh is pale green, firm, fiber-free, and of excellent flavor. The variety is of considerable promise.

AMINI

Amini (No. 4940) is an Indian variety which has been in Hawaii for many years. It is reported to be of good quality, but not prolific. One grafted tree is growing at the station in field B–III.

BISHOP

The Bishop (No. 5247) was introduced as an inarched tree from Tahiti, in December, 1926, by G. P. Wilder. The fruit is reported to be large and of excellent quality.

BOMBAY YELLOW

Bombay Yellow (No. 1029), an Indian variety, was introduced by the station in 1907 through the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture (S. P. I. No. 13348). The variety has not attracted much attention, but the trees are to be found growing in the Territory.

CARABAO

Several introductions of the Carabao (No. 4799) have been made into Hawaii. Although this variety is highly considered elsewhere. it has not attracted attention in Hawaii.

CREDON

The original tree of the Credon (No. 5041) was a seedling of Sandersha. The fruit is large, weighs 2½ to 3 pounds, and is of greenish tint and pleasing aroma and flavor. The fruiting season is in the fall.

CRESCENT

The Crescent (No. 1945) was described by Higgins (*2*, *p. 28*). This Hawaiian variety has attractive fruit and is desirable for further vegetative propagation.

DOUBLE POINT

An excellent variety. The fruit is easily distinguished by two prominent points, one above the other in the region of the nak.

FRENCH (FRENCH WINE)

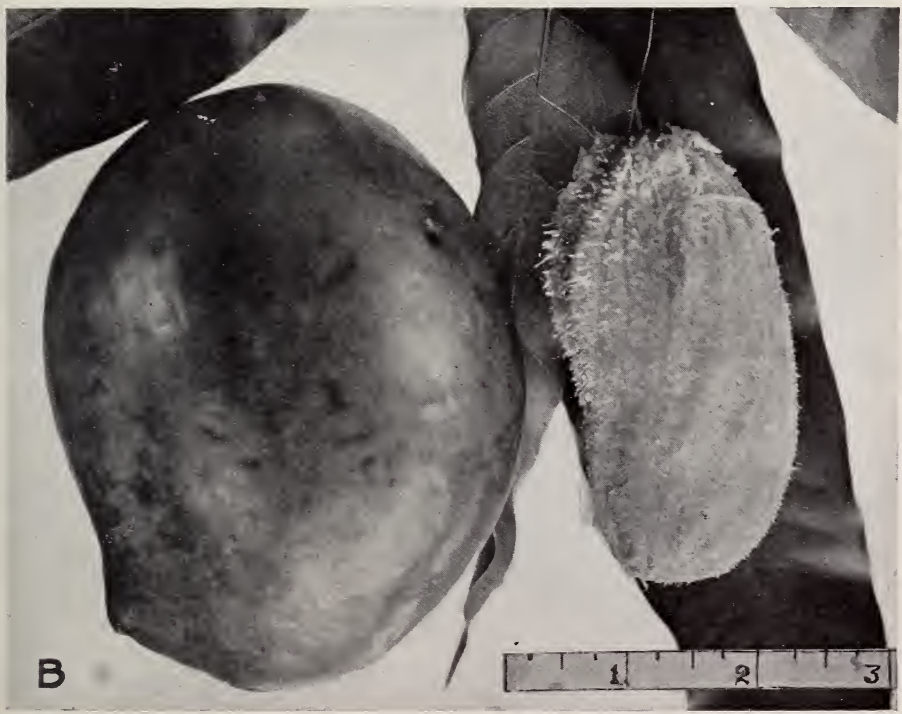
French or French Wine (No. 4816) is of unknown origin. It may be an introduction. It was listed at the station as accession No. 1962 before the variety disappeared in 1920. Since 1920 new propagating material has been obtained locally. It is a desirable variety, worthy of vegetative propagation.

GREEN GAGE

Green Gage (No. 2522) was obtained locally in 1910. The trees are occasionally found growing in the Territory. The quality of the fruit is fair.

JULIE

The Julie (No. 2102) was introduced from Trinidad through the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, as S. P. I. No. 21515. The fruit is of fair quality and the tree prolific, often fruiting very early. Its propagation has not been encouraged because the fruit is usually very susceptible to the attacks of the Mediterranean fruit fly.



A.—Fruit and seed of the Ameeri variety of mango. This variety has been in Hawaii for many years but is as yet little known there. The trees do not seem to be prolific. B.—Ameeri Hybrid is supposed to be a cross between Ameeri and Cambodiana. The fruit is very excellent in many qualities. Seed at right

A.—Fruit and seed of the Manila, which variety of mango is as yet little known in Hawaii. Rain at ripening time causes the fruit to crack. It occasionally is infested with the Mediterranean fruit-fly maggot. B.—Cluster of Hawaiian mangoes typical in form and cluster of the Hawaiian race of mangoes

LUDWIG

The Ludwig (No. 5298) is a new Hawaiian seedling, the original tree of which grows in the Ludwig property, Waialae Avenue, Kaimuki. The fruit is of excellent quality and shows no evidence of the attacks of the Mediterranean fruit fly. The Ludwig is being propagated vegetatively.

MANINI

The first mango variety introduced into Hawaii. Source of the original so-called Hawaiian mangoes. It is illustrated by Wilder (*15, p. 134*).

M'DOUGAL

A new Hawaiian variety of excellent quality. (No. 5280.) The original tree was grown at Waipahu, Oahu. The fruit has been studied at the station and its culture is recommended.

ONO

The original tree (No. 5323) was grown presumably as a Pirie seedling on the R. W. Smith property, Makiki Heights, Honolulu. The tree is vigorous and prolific and the fruit is of fine quality. A great many trees of the variety have been distributed both by the originators and by the station to cooperative growers.

PIRIE SEEDLING

This, the second generation (No. 5146) (pl. 10, B) from the Pirie, was originated by H. L. Lyon, of Honolulu. The fruit is of very fine quality but is somewhat susceptible to attack by the Mediterranean fruit fly. This seedling is worthy of propagation as a variety.

RED SEEDLING

The origin of the Red Seedling (No. 1937) is not recorded. Selected in 1907 and grown in the station orchard. The fruit is of medium size, dark red, and of fair quality. The fruits are unusually marked by a small, oblong depression at the stigmatic point.

ROSA

The Rosa (No. 5040) usually produces a crop out of the regular summer season. The origin is not known. From the size, shape, and color, the determination of its relation to other varieties is difficult.

SMITH-WOOTTEN

This variety (No. 1485) has been bearing at the station for many years. It is prolific, and the fruit is small but excellent. The seed is especially interesting, because the husk is very thin and is therefore easily removed.

SPONGE-CAKE

A variety considerably grown in the Territory. The fruit is large, light in texture, and of pleasing aroma and flavor. Although the original tree was a seedling, the fruit has many of the characters of the Sandersha.

STRAWBERRY

Although the Strawberry (No. 1931) was introduced as a distinct variety, the fruit, like that of Peter's No. 1, appears to be synonymous with that of the Pirie.

WATERHOUSE

The Waterhouse (No. 5333) is a comparatively new vareity of Hawaiian mango. Originated with Mrs. John Waterhouse, Honolulu.

WHELAN

The Whelan (No. 5218) originated at Waipahu, Oahu. The fruit is of excellent quality, and is Hawaiian in type.

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